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INSTRUCTION MANUAL

751L/1501L-M

California INSTRUMENTS

Invertron® AC POWER EQUIPMENT

Convertron® DC POWER EQUIPMENT

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California INSTRUMENTS

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INSTRUCTION MANUAL

751L/1501L-M

Invertron®

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SECTION 1

INTRODUCTION AND SPECIFICATIONS

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the California Instruments Model 1501L-1M and Model 751L-1M. The 1501L-1M and 751L-1M will hereafter be referred to as the AC Power Source. The differences between 751L and 1501L will be detailed throughout the manual.

1.2 GENERAL DESCRIPTION

This instrument is a high efficiency power source that provides a low distortion sine wave output. The AC Power Source can supply up to 1500VA. Full power is available from either a 0 to 135 volt range or 0 to 270 volt range. Full power is available from 45 Hz to 5 KHz. The AC Power Source is illustrated in Figure 1-1.

1.3 ACCESSORY EQUIPMENT/RACK SLIDES

Zero Manufacturing Company Model CTN-1-20-E94 rack slides may be attached to the sides of the power source using 8-32 X 3/8 flat head screws

1.4 SPECIFICATIONS

Table 1-1 contains the operation specifications of the AC Power Source. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, constant line voltages and under no-load conditions unless specified otherwise.

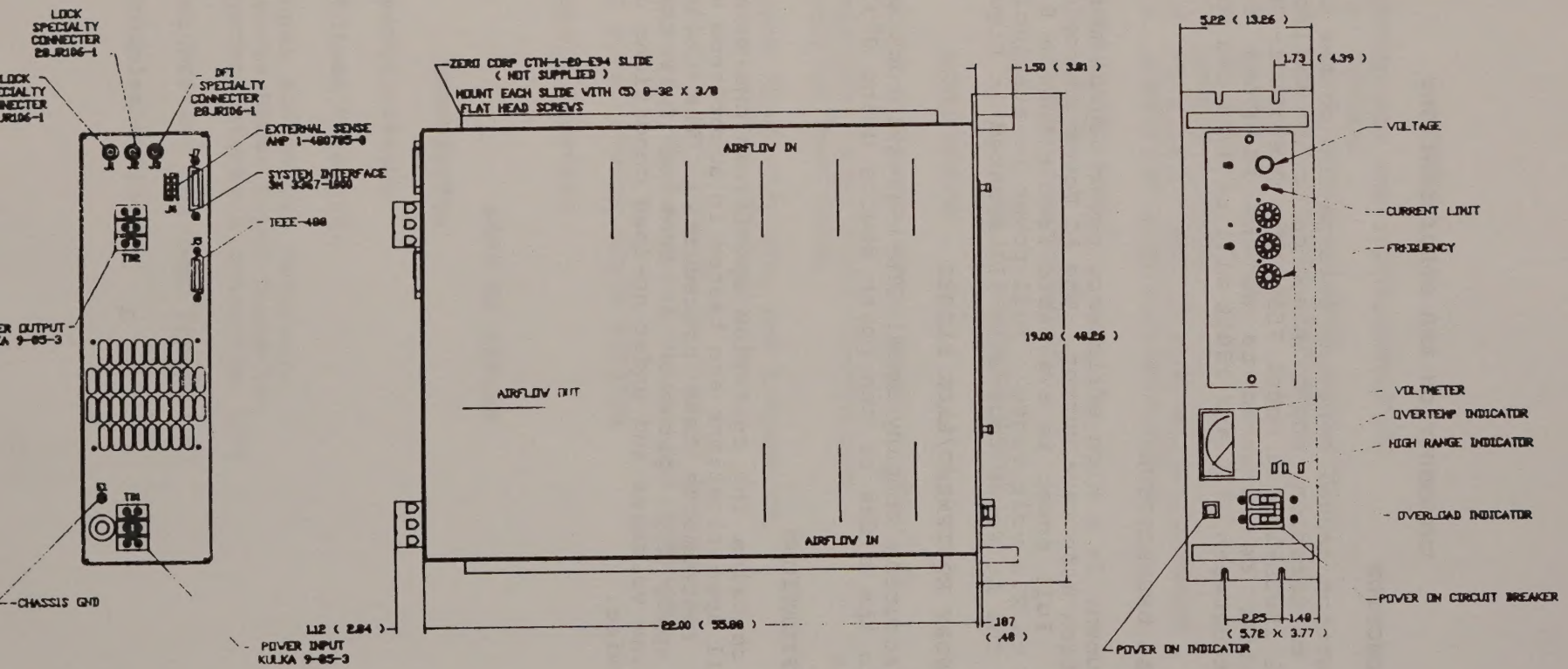


FIGURE 1-1
CALIFORNIA INSTRUMENTS 1501L/751L

TABLE 1-1

1501L-M/751L-M SPECIFICATIONS

ELECTRICAL

All specification apply using external sense, 25±1°C, constant line and load conditions, after 15 minute warmup, unless otherwise specified.

Output

	Total Power		Total current 135 volt		270 volt	
	35°C	50°C	35°C	50°C	35°C	50°C
1501L	1667	1500	12.34	11.12	6.18	5.56
751L	835	750	6.18	5.56	3.09	2.78

Power factor: 0 to 1.0.

	Peak current repetitive		Peak current nonrepetitive	
	135V	270V	135V	270V
1501L	27.8	13.9	30.0	15.0
751L	13.9	6.95	15.0	7.5

Voltage range: 135/270 volts std
67.5/135 LV option.
156/312 HV option.
200/400 EHV option.

Total Distortion (to 300 KHz)
1% up to 2 KHz,
2% up to 5 KHz.

Line regulation: 0.02% of full scale for ±10% of input line voltage.

Load regulation: 0.05% of full scale from no load to full load.

Frequency range: 45 Hz to 5 KHz at 50°C max current.
45 Hz to 2 KHz at 35°C max current.
45 Hz to 1 KHz for EHV option.

Frequency accuracy: ±0.001% of programmed value.

SPECIFICATIONS (continued)

Output overload:	Will operate at constant current.
Output short circuit	Immediate shutdown with automatic recovery.
Invalid frequency	Immediate shutdown.
Sense Line Fault:	Output voltage limit to 115% of program value.
Overtemperature:	Default to 0 volts and open output relay (1501L, 751L if option installed), no recovery.
Measurements:	Voltmeter, analog panel meter. Accuracy 5% of full scale.

SUPPLEMENTAL SPECIFICATIONS

ELECTRICAL

Input

Line voltage: 103 - 127 VAC,
207 - 253 VAC.

Current(pf=0.6, eff=75%, line V=103, full load): 32 Amps

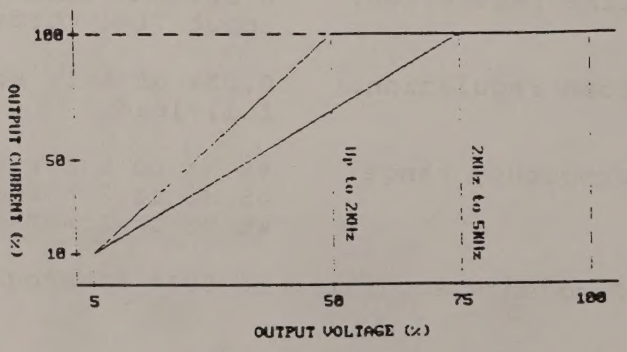
Line frequency: 47 - 440 Hz.

Efficiency: 75% typical.

Surge current (turn-on) 185 amps at high line voltage.

Output

Output Current /Output Voltage
See graph below



SUPPLEMENTAL SPECIFICATIONS (continued)

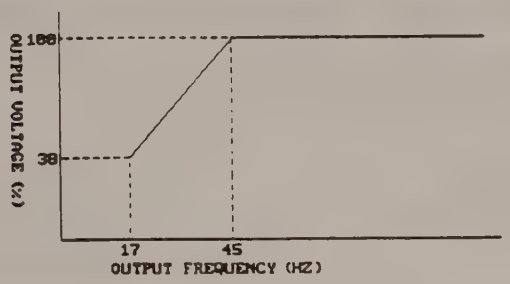
Output noise (20 KHz to 1 MHz at full load)
200 mv rms (typical)

Voltage temperature coefficient:
±0.02 of full scale/°C.

Voltage stability (24 hours):
±0.015% of full scale under constant load, line and temp.

Steady state output impedance:
= (voltage range * 0.0005)/load current.

Output Voltage /Frequency
See graph below



Voltage settling Time:
(from start of voltage change from 5.0 Vrms or higher voltage within 2% of final value)
No load: 16 msec,
Full load: 0.3 sec.
(16 msec to within 15% of final value)

Frequency temperature coefficient:
±5 ppm per degree C.

Frequency Stability:
±15 ppm per year.

Isolation: 500 Volts rms input to output.

SUPPLEMENTAL SPECIFICATIONS (continued)

CONTROL

Front panel controls:

- Circuit Breaker.
- 10 Turns amplitude potentiometer.
- 3 position frequency range switch.
- 3 Frequency setting rotary switches.
- 1 turn current limit potentiometer.
- 300 volt analogue meter.

Functions

Voltage:
Amplitude varied by 10 turn potentiometer.

Voltage Range:
Set by toggle switch.

Frequency:

Range:	45 to 5000 Hz (2000Hz EHV).
Resolution:	0.1 Hz from 45 to 99.9 Hz, 1 Hz from 100 to 999 Hz, 10 Hz from 1000 to 5000 Hz.

Current Limit:
varied from 0 to 100% of range by single turn potentiometer

Range:	1501L	0 to 11.12 Amp at 135V range ✓
		0 to 5.56 Amp at 270V range
	751L	0 to 5.56 Amp at 135V range
		0 to 2.78 Amp at 270V range.

FEATURES:

Remote shut down:
A logic low input set the output to 0 volt and open the output relay if applicable.

Output Relay(1501L only, 751L option):
Normally close at power up. Output Relay is controlled by remote shutdown.

Remote Sense:
Will compensate for 10% of drop in output voltage.

External Modulation:
External 0 to 10 Vrms, DC to Output frequency signal gives 0 to 10% amplitude modulation.

SUPPLEMENTAL SPECIFICATIONS (continued)

Indicators:
Power on, high voltage range, overtemperature, output overload, frequency limit.

MECHANICAL

Dimensions:	5.25 x 19 x 22 + 1 for connector.
Weight:	75 lbs (70 lbs 751L)
Material:	Aluminum front panel, steel chassis.
Finish:	Gray 26440 per Fed Std 595.
Air intake/exhaust:	Sides/rear.
Modularity:	Modules interconnected with motherboard.
Connectors:	Input - Kulka 9-85-3. Output - Kulka 9-85-3. Sense - Amp 1-480705-1. Interface - 3M3367-1000.
Chassis slides:	Zero Manufacturing CTN-1-20-E94.

ENVIRONMENTAL AND QUALITY

Operating temperature:	0 to 50°C.
Storage temperature:	-40 to 85°C.
Operating altitude:	0 to 6000 feet.

OPTIONS

Output Voltage Ranges:

High Voltage:	156/312
Low Voltage:	67.5/135
Extra High voltage:	200/400 (1000 Hz max Frequency)

LK: Allows unit to operate as a master or slave in synchronization with other controllers

RPV: Remote program voltage; 0 to 10 vdc sets output to 0 to 100% of range. External modulation cannot be used if RPV option is installed.

Output Relay: 751L only.(std for 1501L)

SYSTEMS

None

CAUTION

Voltages up to 270 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.2 POWER REQUIREMENTS

2.2.1 AC LINE VOLTAGE

The AC Power Source has been designed to operate from either of the following AC line voltage ranges:

1) 104 to 126 volts
2) 207 to 253 volts.

CAUTION

The AC Power Source will be damaged if it is operated at an input voltage that is outside its configured input range.

The input voltage range is set at the factory. Section 2.3 gives the procedure to change the input voltage range.

2.2.2 LINE FREQUENCY OPERATING RANGE

The AC Power Source has been designed to operate over the line frequency range from 47 Hz to 440 Hz.

2.2.3 INPUT POWER

The input power to the AC Power Source depends upon line and load conditions and may be as high as 2000 watts.

2.3 INPUT VOLTAGE RANGE SELECTION

WARNING

Voltages up to 360 VDC and 270 VAC are present in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electric circuits when power is applied. Servicing should only be performed by trained personnel.

The input voltage range is configured by two wires and eight jumpers. See Figure 6-1 for the location of the A6 board (DC Supply) where the jumpers are located.

2.3.1 LOW INPUT VOLTAGE RANGE CONFIGURATION

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The low input voltage range is set by making the following connections inside the power source:

Wire W5	4005-050-005	From CB1B-LN to A6-E2.
Wire W11	4005-050-011	From DS1 to A6-E7.

Jumper A6-J1	From 2 to 5.
Jumper A6-J1	From 3 to 4.
Jumper A6-J2	From 2 to 5.
Jumper A6-J2	From 3 to 4.
Jumper A6-J3	From 2 to 5.
Jumper A6-J3	From 3 to 4.
Jumper A6-J4	From 2 to 5.
Jumper A6-J4	From 3 to 4.

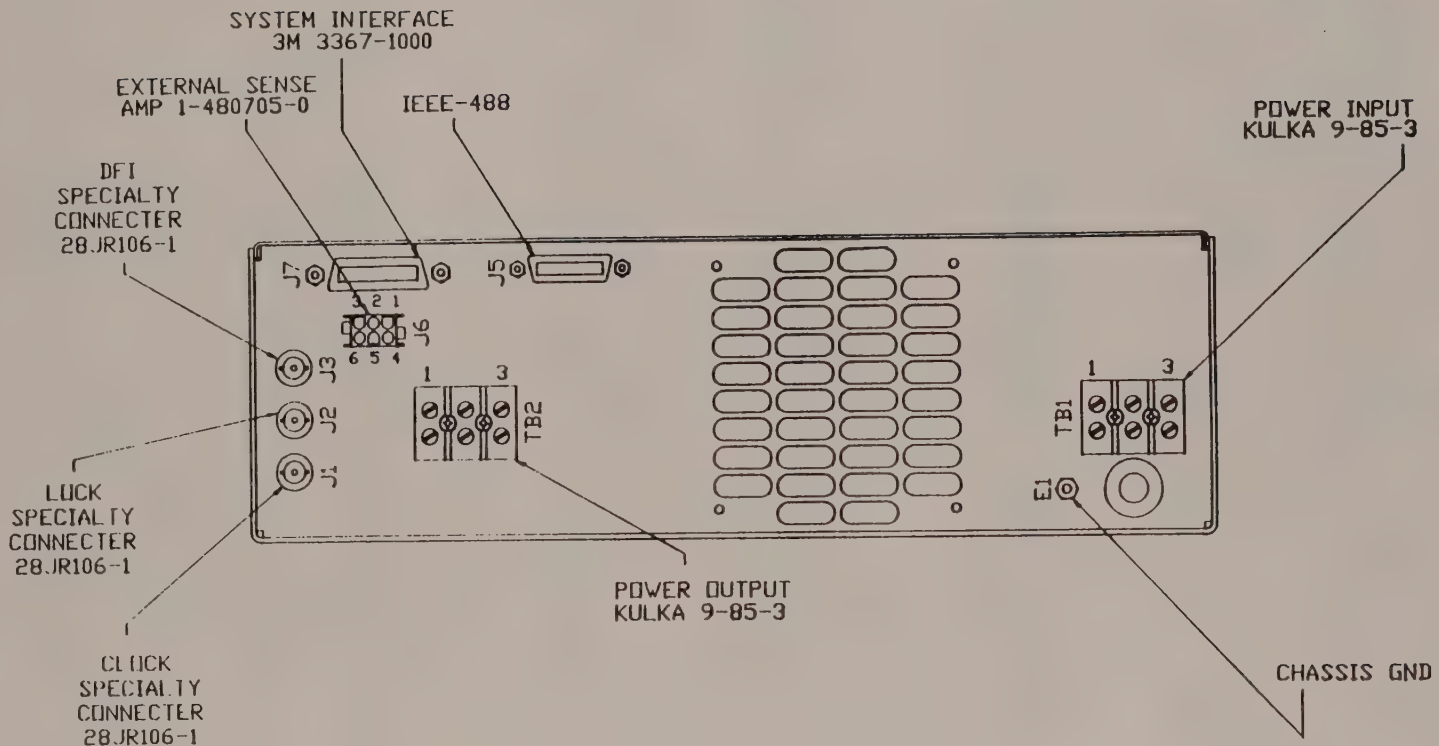
2.3.2 HIGH INPUT VOLTAGE RANGE CONFIGURATION

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The high input voltage range is set by making the following connections inside the power source:

Wire W5	4005-050-005	From CB1B-LN to CR1-AC.
Wire W11	4005-050-011	From DS1 to A6-E4.

Jumper A6-J1	From 1 to 6.
Jumper A6-J1	From 2 to 3.
Jumper A6-J2	From 1 to 6.
Jumper A6-J2	From 2 to 3.
Jumper A6-J3	From 1 to 6.
Jumper A6-J3	From 2 to 3.
Jumper A6-J4	From 1 to 6.
Jumper A6-J4	From 2 to 3.



TB1

PIN	FUNCTION
1	HI INPUT
2	LO INPUT
3	GND

J6

PIN	FUNCTION
1	ø C SENSE
2	ø B SENSE
3	ø NEUT SENSE
4	ø A SENSE

TB2

PIN	FUNCTION
1	HI OUTPUT
2	LO OUTPUT
3	GND

FIGURE 2-1
1501L REAR PANEL CONNECTIONS

2.4 MECHANICAL INSTALLATION

The power source has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in paragraph 1-3. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 1-1.

2.5 INPUT WIRING

The AC Power Source must be operated from a three-wire single phase service. The mains source must have a current rating greater than or equal to the AC Power System circuit breaker, 30 amps. Refer to Figure 2-1 for the input power connections.

2.6 OUTPUT CONNECTIONS

The output terminal block, TB1, is located at the rear of the power source. All load connections must be made at TB1. The remote sense inputs allow the power source output voltages to be monitored directly at the load and must be connected. The remote sense wires are connected at J3 on the rear panel.

The output power cables must be large enough to prevent a voltage difference greater than 3.5 VRMS between TB1 and the voltage between Remote Sense HI and LO input. Table 2-1 shows the maximum length of the output wires. The table assumes the Remote Sense input is connected at the load.

TABLE 2-1

MINIMUM WIRE SIZE

	WIRE GAGE (AWG)	MAXIMUM LENGTH (in feet) WIRE BETWEEN OUTPUT AND LOAD
11.11	20	14
11.11	14	59
11.11	12	94

The Remote Sense inputs must be connected. Failure to connect the Remote sense input will result in poor Load Regulation and Line Regulation.

2.7 OUTPUT VOLTAGE RANGES

The standard voltage ranges for this AC Power Source are 135 and 270. Selecting of the 270 volt range causes the front panel "HIGH RANGE" lamp to illuminate. The range may be changed from the front panel toggle switch. Each time the output voltage range is changed the output voltage is momentarily set to zero to reduce relay contact wear.

2.8 FUNCTION TEST

Refer to Figure 2-2 for the test setup.

Perform the following test sequence.

1) Apply the AC line power and turn on the front panel circuit breaker. No loads should be connected to the output terminal block.

2) Verify that the POWER ON lamp is lit.

3) With the front panel control, select the high voltage range by toggling the Voltage Range switch.

4) Verify the HIGH RANGE lamp is lit.

5) Program the output to 270 volts by adjusting the front panel Amplitude control knob.

6) Verify that the front panel voltmeter indicates approximately 270 volts.

7) Program the AC Power Source to the 135 volt range by toggling the Voltage Range switch to the Low position.

8) Program the output to 135 volts by adjusting the front panel Amplitude control knob.

9) Observe the output with the oscilloscope or distortion analyzer. The output should be a clean sine wave having less than 1.0% distortion.

10) Apply a full load (12.4 ohms, 1500 watts for 1501L and 24.8 ohms, 750 watts for 751L). Verify that the output voltage remains within 0.067 volts of the no-load voltage. The waveforms shall still appear clean on the oscilloscope and have less than 1% distortion.

11) Locate the Current Limit pot at the front panel. Adjust the Current Limit pot to 50% Current Limit.

12) Observe the OVERLOAD light in the power source. It should be on.

13) Program the output voltage to zero voltage.

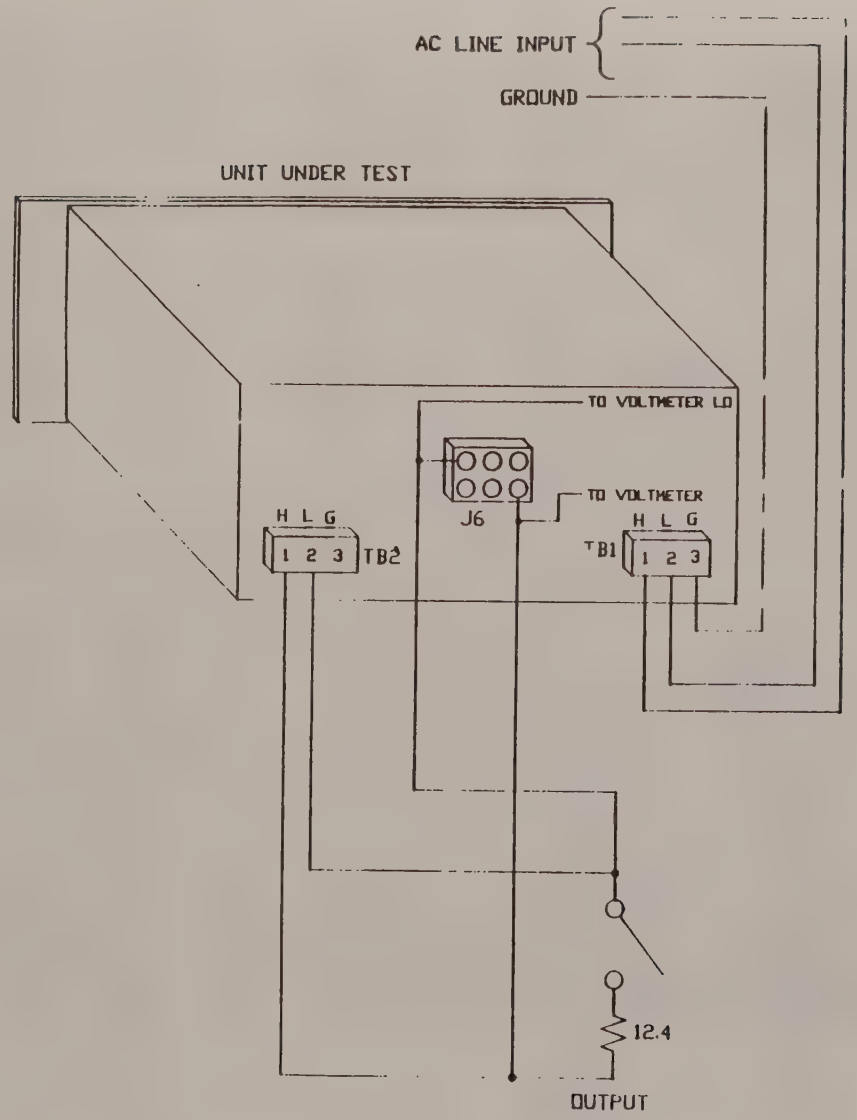


FIGURE 2-2
TEST SETUP

SECTION 3

OPERATION

3.1 GENERAL

The AC Power Source may be programmed from the front panel. The rear panel of the AC Power Source holds the power input and output terminals, remote sense connector, system interface connector and the chassis ground stud.

3.2 FRONT PANEL CONTROLS

Refer to Figure 3-1 for an illustration of the AC Power Source front panel.

CIRCUIT BREAKER

The circuit breaker switches power to the AC power source. The circuit breaker will trip in the event that a fault within the power source causes an excessive draw of current.

POWER ON LAMP

The power on lamp illuminates when the circuit breaker is switched on and the power source begins to draw input power.

VOLTMETER

The average responding AC voltmeter is connected directly to the power source output. Full scale deflection is 300 volts. The voltmeter will indicate no voltage if the output relay is open.

INDICATOR LAMPS

OVERTEMP: This lamp illuminates when the temperature of the power amplifier heatsink has surpassed a maximum set level. The overheated amplifier will shut down until its heatsink has cooled to a safe operating temperature. The amplifier will recover automatically.

OVERLOAD: This lamp illuminates when the power source has limited the output current to the preset program level. The output waveform will clip and remain clipped until the load is reduced to the program value.

HIGH RANGE: This lamp illuminates when the power source has switched to the high voltage setting.

FREQUENCY SELECT DIALS: Three dial switches are used to set the output frequency.

The output frequency is set within the frequency range selected by the Frequency Range select switch.

An LED is set between the second and third LED for Range 45.0 to 99.9 Hz.

An LED is set after the third digit for range 100 to 199 Hz.

An LED is set between the first and second digit for range 1.00 KHz to 5.00 KHz.

FREQUENCY RANGE SELECT: This three-position switch selects the desired Frequency Range as specified by the previous paragraph.

VOLTAGE AMPLITUDE Knob: This knob controls the output amplitude from 0 to full scale.

VOLTAGE RANGE Switch: The Voltage Range switch select the low voltage range or the high voltage range.

CURRENT LIMIT Knob: This know controls the desired current limit. The current setting varies between 0 and maximum current setting for the power source.

LIMIT LAMP: This lamp is lit when the programming frequency value is above the maximum frequency limit of the oscillator. This maximum frequency limit is set at the factory.

This lamp is also lit momentarily when a range change is selected or during the power turn on. The output is disabled when this lamp is lit.

3.3 REAR PANEL CONNECTIONS

TB1 is the terminal block for the three input wire. Terminal 1 connects to the High and Low input. Terminal 3 is the chassis connection which should be connected to the input mains ground.

TB2 is the power output terminal block. Refer to Table 3-1 for identification of the TB1 and TB2 terminals.

TB1	DESCRIPTION	TB2	DESCRIPTION
1	Input HI	1	Output HI
2	Input LO	2	Output LO
3	Chassis Ground	3	Chassis Ground

TABLE 3-1

J6 is the remote sense input connector. The remote sense input must be connected to the respective AC Power Source output. If the inputs are not connected, a poor Line and Load Regulation will result.

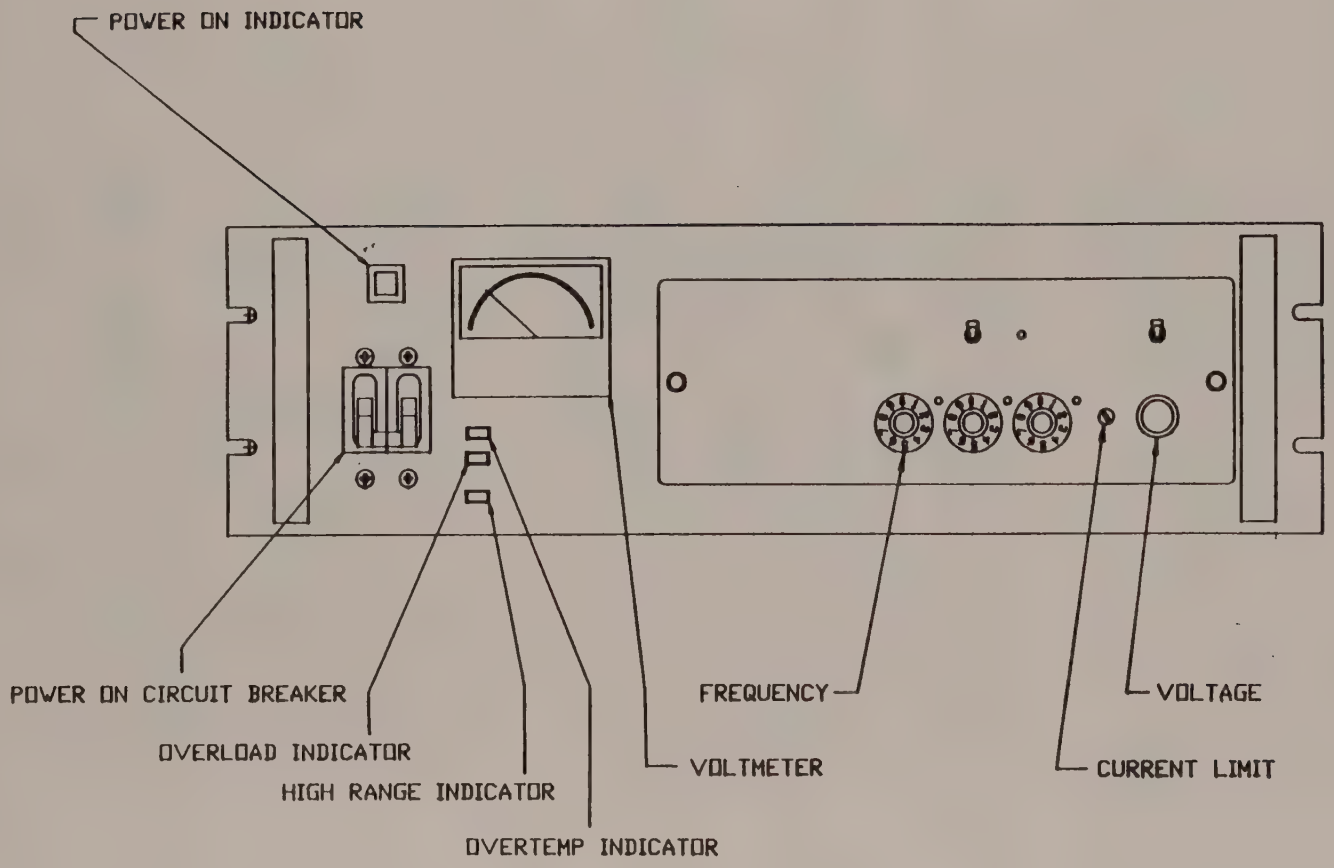


FIGURE 3-1
FRONT PANEL CONTROLS AND INDICATORS

J6	DESCRIPTION	CONNECT TO:
1		Do not connect
2		Do not connect
3	Sense LO	Output LO
4	Sense HI	Output HI
5	No Connection	- - - - -
6	No Connection	- - - - -

TABLE 3-2

J7 is the System Interface connector. Table 3-3 identifies the pins of the System Interface connector.

J7	Description
1	Analog Common
2	MR B, Phase B amplifier input signal, not used
3	Analog Common
4	CS B, Phase B current sum, not used
5	CT Common, Current Transformer Common
6	OS B, Oscillator Phase B output, not used
7	Analog Common
8	CL B, Phase B DC current limit, not used
9	RPV, Remote Programming Voltage
10	$\overline{\text{OVR TEMP}}$ Overtemperature indication
11	$\overline{\text{CNF}}$, Output relay (1501L, 751L if option installed)
12	FLT C, Phase C current limit fault, not used
13	FLT A, Phase A current limit fault
14	F STB LO, Function Sync output LO
15	EX SYNC LO, External Sync input LO
16	No connection
17	No connection
18	No connection
19	MR C, Phase C amplifier input signal, not used
20	MR A, Phase A amplifier input signal
21	CS C, Phase C current sum, not used
22	CS A, Phase A current sum
23	OS C, Oscillator Phase C output, not used
24	OS A, Oscillator Phase A output
25	CL C, Phase C DC current limit, not used
26	CL A, Phase A DC current limit
27	D COM, Digital Common
28	$\overline{\text{RNG HI}}$ High Voltage range
30	FLT B, Phase B current limit fault, not used
31	F STB HI. Function Strobe output HI
32	EX SYNC HI, External Sync input HI
36	REMOTE SHUTDOWN

TABLE 3-3

SYSTEM INTERFACE CONNECTOR (J7)

J7-1 ANALOG COMMON: This is the common for all analog signals on the connector.

J7-3 ANALOG COMMON: See J7-1.

J7-5 CT COMMON:

J7-7 ANALOG COMMON: See J7-1.

J7-9 RPV: This input is used for an optional Remote program of the output. With this option the output voltage may be controlled with a DC voltage.

J7-10 $\overline{\text{OVR TEMP}}$: A logic low output to indicate an overtemperature condition.

J7-11 $\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open.

J7-13 FLT A: Make no connections.

J7-14 F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.

J7-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J7-31.

J7-16 No connection.

J7-17 No connection.

J7-18 No connection.

J7-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J7-22 CS A: Current sum for the phase A output. Make no connection to this pin.

J7-24 OS A: This is the output from the internal phase A oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full- scale output voltage.

J7-26 CL A: A DC level from the oscillator used to set the current limit for phase A.

J7-27 D COM: Digital common.

J7-28 RNG HI: A logic output from the internal oscillator to control the Range relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.

J7-29 REMOTE SHUTDOWN: A is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0.0 volts and the output relays to open for 1501L (751L, if option is installed). A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J7-27 (D COM) will simulate a logic low state.

J7-31 F STB HI: Function Sync High signal. This is the collector lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (<.4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC must be connected to J7, pin 31. J7, pin 14, is the common output. Refer to Figure 3-2.

J7-32 EX SYNC HI: External Sync Low signal. This is an input that can be used to synchronize the outputs of the AC Power Source. This input requires a logic high level of at least +4.5 VDC at 1.5 ma. The input should have a duty cycle 50 ±10%. J7-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

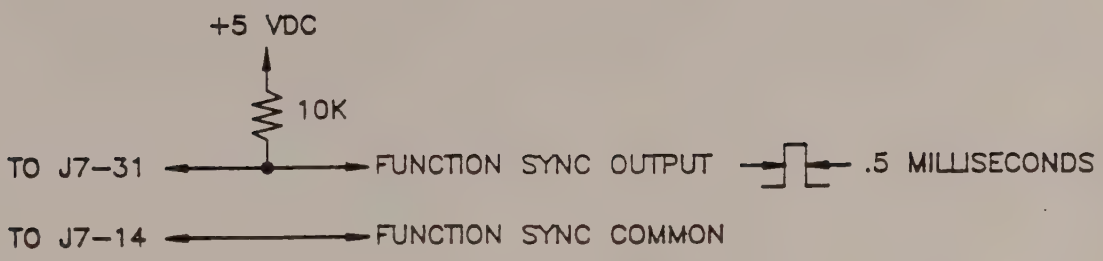


Figure 3-2

FUNCTION SYNC CONNECTIONS

CAUTION

Voltages up to 270 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 4

CALIBRATION PROCEDURE

4.1 GENERAL

The following calibration or any part of it may be performed to ensure that the AC power source remains within specification.

This procedure should always be performed after any repair has been made to the unit but only when the power source is functioning normally. Table 4-1 lists the paragraph titles and page numbers for calibration and test procedure.

PARAGRAPH	PROCEDURE
4.3	GAIN ADJUSTMENT
4.4	CURRENT TRANSFORMER BURDEN ADJUSTMENT
4.5	CURRENT LIMIT ADJUSTMENT

TABLE 4-1

This calibration procedure assumes that the power source is tested at 25°C ambient temperature on the 135 volts range. Performance is similar on the 270 range. Output voltage measurements must be made at the power controller voltage sense point. Otherwise, voltage drops in output wiring may cause inaccurate measurements.

4.2 TEST EQUIPMENT REQUIRED

The following test equipment is required for performing the calibration procedure.

Digital Voltmeter (DVM)
Resistive Load: 12.1 ohm, 1500 watt
Precision Current Transformer: Pearson 110
Oscilloscope: Kikusui COS6100

4.3 GAIN ADJUSTMENTS

A gain adjust potentiometer is provided for the AC power source amplifier. For the location of the gain adjustment potentiometer see Figure 4-1.

1.0 Remove all loads from the power source. Turn the power on.

2.0 Monitor the output voltage between the output high and low.

3.0 With the Remote Sense lines connected, adjust the output voltage for 120 volts.

4.0 Disconnect the Remote Sense lines and adjust R18 on the Current Limit Board until the output measures 132 volts ±0.25 volts.

5.0 Reconnect the Remote Sense leads.

4.4 CURRENT TRANSFORMER BURDEN ADJUSTMENT

This adjustment is not required unless it is unable to adjust the Current Limit in the following section.

1. Monitor the output current with the Current Transformer and AC DVM.

2. Turn on the AC input to the power source. Program the output for 135.0V rms and 60 Hz.

3. Apply a resistive load of 12.1 ohms to the output.

4. Measure the output voltage between TP10 (GND) and TP1 on the Current Limit board assembly (A5). Refer to Figure 4-1.

5. Adjust R1 on the Range Relay assembly so that TP10 will measure 1 volts = 10 amps.

4.5 CURRENT LIMIT CALIBRATION (1501L only)

1.0 Program the output for 135.0 volts and 60 Hz and monitor the output current.

2.0 Apply a full resistive load at the output 11Ω (12.2 Amp) and turn the Current Limit adjustment knob to its maximum clockwise position.

3.0 Adjust R17 on the Current Limit assembly board so that the OVERLOAD light starts to glow.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

An explanation of the circuits within the AC Power Source is given in this section. Refer to Figure 5-1 for the block diagram of the AC Power Source.

5.2 OVERALL DESCRIPTION

Input power at the rear panel is routed through the circuit breaker to the high current rectifier and the Power Supply Assembly, A6. The various DC supply outputs go to the Mother Board, A4, and are directed to other modules.

The Manual Oscillator Assembly, A8, generates the oscillator waveforms for each phase, sets frequency amplitude and current limit levels. The oscillator assembly is connected to the rest of the power source through the Oscillator Interface Board, A3. The Manual Oscillator Assembly is made of two printed circuit Boards that are interconnected by a ribbon cable.

The Amplifier Module, A7, takes its DC supply voltages and input signal from the Mother Board, A4. It produces the high power output for the primary of the output transformer, T1. The output is routed through the Mother Board to the output transformer.

The Range Relay Board is identified as A2. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The output from the AC Power Source is taken from the Range Relay Board.

The Current Limit Board is identified by A5. This board controls the amplifier gain and the programmable current limit.

5.3 INPUT POWER SUPPLY

This assembly is identified as A6. It generates the high power +300 VDC supply.

The input power supply also has circuits that generate the DC voltages identified as ±18V, ±15VSW, +8VSW and +8V.

The ±18V supplies are used for oscillator modules and the Current Limit Board. The +8V supply is used for the oscillator module. The ±15VSW and +8VSW supplies are used for the Amplifier Module.

The input power supply generates a 50 VDC and 15VSW1 from the 300 volt supply. The 50 VDC is used for fan and relay operation, +15VSW1 is used for the gate drive signal in the Amplifier Module.

5.4 CURRENT LIMIT BOARD

The Current Limit Board receives the oscillator signal from the Oscillator Module. The signal is directed to the input of the power amplifier. A gain adjustment is located on the board.

The current limit circuit is also located on the Current Limit Board. The circuit receives a DC signal from the Oscillator Module that is proportional to the current limit value. The DC signal is compared to the output current.

If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power Source to operate at a constant current. If the output current limits the output voltage to 90% of the programmed voltage, an amplitude fault will be generated.

5.5 INDICATOR BOARD

The Indicator Board, A1, has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

5.6 RANGE RELAY BOARD

The Range Relay Board has all of the AC Power Source relays. These relays are operated from +50 VDC. The output relay is controlled by the CNF Logic Line. The range relay is controlled by RNG HI line.

There is a current transformer on the Range Relay Board. This transformer generates an AC voltage that is proportional to the output current. A 10 amp load current is represented by 1.00 VAC at the output of the current transformer.

5.7 AMPLIFIER MODULE

The AC Power Source has an amplifier module. The amplifier module operates in a switch mode to obtain high efficiency. The switchmode amplifier operates at 200 KHz.

The Amplifier Module obtains its input signal from the Current Limit Board. A 4.6 VRMS input signal will generate a full scale output voltage at the output of the AC Power Source and 100.0 VRMS on the primary of the output transformer.

The Amplifier Module requires a 300 VDC, ±15VSW, +8VSW and +15VSW1 supplies. The +300 VDC supply comes from the input power supply through a 10 amp fuse on the Power Mother Board.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100 degrees C, a control signal is sent to the Oscillator Module. A logic low on the OVERTEMP control line will cause the error message TEMP FAULT to be generated.

5.8 OSCILLATOR MODULE

The Oscillator Module is identified with the reference designator, A8. The module consists of two printed circuit boards. These assemblies are interconnected with a small ribbon cable.

The Control board is mounted to the front panel and has all the Control knobs and potentiometers that are needed to control the power source. The Control board is connected to the Waveform Generator board via a cable.

The Waveform Generator board generates the sine wave that is required to control the output, amplitude, frequency and current limit.

5.8.1 Control Board

The Control board is mounted to a small panel that is mounted to the front panel of the power source. The small panel holds the Frequency Select dial, the Frequency Range select, the Amplitude Control, the Amplitude Range, and the Current Limit potentiometer.

The Control board generates a frequency that is 10240 times the dial setting. With the Frequency Range Select, the Waveform Board divides this frequency by 1, 10 or 100 depending on the range selection.

The Voltage Range switch controls the range relay.

5.8.2 Waveform Generator Board

The Waveform Generator Board will divide the frequency received from the Control Board by 1, 10 and 100 depending on the Frequency Range setting. The resulting waveform is square wave that has a frequency 1024 times the desired frequency.

A divide down of this frequency is used to control the switch capacitor filter.

The clock is further divided down to generate the output frequency.

This clock is used to control the positive and negative reference to the switch capacitor filter. This reference is equal to the peak value of the sine wave.

Other circuits on the Waveform Generator board are used to detect frequency programmed outside the Range Limit. The oscillator output will go to zero until the programmed frequency is corrected. The oscillator output will interrupt momentarily during a voltage range change to reduce stress on the relay.

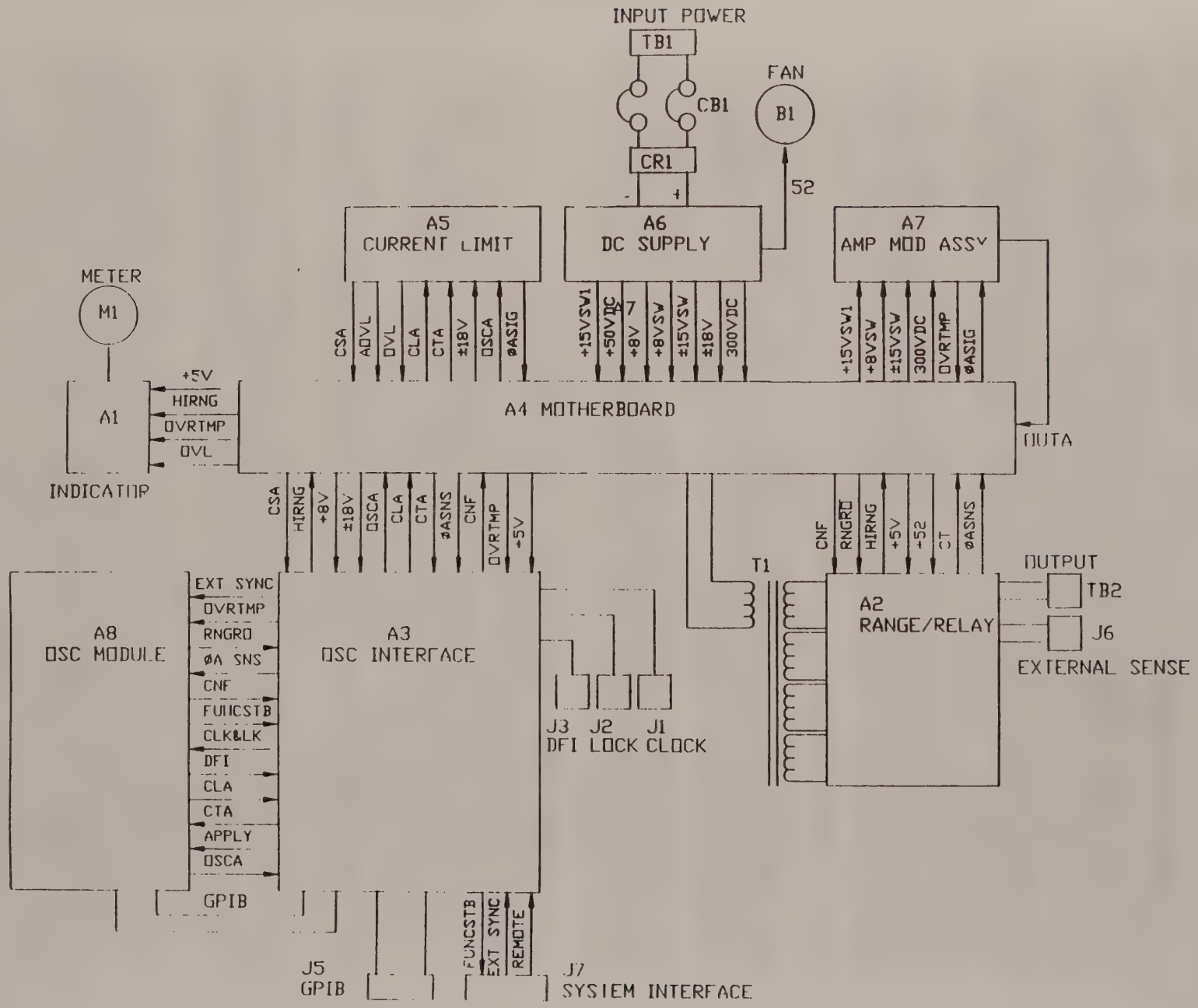

INPUT POWER
TB1
CB1
FAN
B1
CR1
52
A5
CURRENT LIMIT
A6
DC SUPPLY
A7
AMP MOD ASSY
METER
M1
A1
INDICATOR
+5V
HIRNG
OVRTMP
OVL
CSA
ADVL
DVL
CLA
CTA
±18V
OSCA
øASIG
+15VSW1
+50VDC
+8V
+8VSW
±15VSW
300VDC
A4 MOTHERBOARD
OUTA
HIRNG
+8V
OSCA
øASNS
CNF
+5V
RNGRD
-52
CT
T1
OUTPUT
TB2
J6
EXTERNAL SENSE
A2
RANGE/RELAY
A8
OSC MODULE
EXT SYNC
RNGRD
øA SNS
FUNCSTB
CLK&LK
DFI
APPLY
A3
OSC INTERFACE
J3 J2 J1
DFI LOCK CLOCK
GPIB
J5
GPIB
FUNCSTB
EXT SYNC
REMOTE
J7
SYSTEM INTERFACE

FIGURE 5-1

CAUTION

Voltages up to 270 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power Source does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

TABLE 6-1

PARAGRAPH	PROBLEM	PAGE
6.2	Poor Output Voltage Regulation	29
6.3	Overtemperature Lamp On	29
6.4	Overload Lamp On	30
6-5	Distorted Output	30
6.6	No Output	30

6.2 POOR OUTPUT VOLTAGE REGULATION

If the AC Power Source exhibits poor voltage regulation the following item may be at fault:

1. The Remote Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation check.

   SOLUTION: Connect AC voltmeter to Remote Sense lines.

6.3 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following may be at fault:

1. Ambient temperature is too high.

   SOLUTION: Operate power source between 0 and 55 degrees C.

2. Fan or ventilation holes are blocked.

   SOLUTION: Remove obstructions.

3. Fan not working.

   SOLUTION: Replace fan. Consult factory.

6.4 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the output load current has exceeded the programmed current limit value. If the AC Power Source OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

   SOLUTION: Remove the overload.

2. The current limit level is set too low for the load being driven.

   SOLUTION: Readjust the current limit level to a higher level.

6.5 DISTORTED OUTPUT

The AC Power Source output may have a distorted sine wave from the following causes:

1. The power source output is overloaded.

   SOLUTION: Remove the overload or set the current limit to a higher value. Observe power source capabilities. See Section 1.

2. The crest factor of the load current exceeds 2.5. With this condition the distortion will be much higher at frequencies above 100 Hz.

   SOLUTION: Reduce the load or set the current limit to a higher value.

6.6 NO OUTPUT

If the AC Power Source has no output at the rear panel terminal block, TB2, the following items may be at fault:

1. The Amplitude Control knob is set for minimum output voltage.

   SOLUTION: Increase the Amplitude Control.

2. The limit LED on the control panel is lit.

   SOLUTION: Change the frequency until the limit LED will turn off. The output amplitude will go to zero when the limit is on.

3. There is no input to the power amplifiers from the oscillator. Check the oscillator signals at the system interface connector:

   J7-24 Oscillator Signal
   J7-7 Oscillator common/return

   Program 135.0 volts on the 135 volt range. The signal should be 4.74 ±0.5 VAC.

   SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6.10.

   SOLUTION: If the signal at the System Interface connector is greater than 4.74 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6.1.

4. The internal fuse, F1, has failed.

   SOLUTION: Replace the fuse.

6.7 MODULE REMOVAL

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Module, A7, with the insulator removed.

6.8 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the Oscillator Module follow the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker.

2. Remove the front (Oscillator Module front panel and Control board) by loosening the two captive screws on its front panel.

3. Unplug the Oscillator Module, A8, by sliding out the Waveform board with the Control board.

4. The module is now removed. To replace the module follow these steps in reverse order.

6.9 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that indicates the failure of the amplifier module (assembly A7) check the condition of the +300 VDC fuse before replacing the amplifier. Refer to Figure 6- 1 for the location of the fuse.

If it is determined that the amplifier module must be replaced perform the following procedure:

1. Turn off the input circuit breaker.

2. Remove the AC Power Source top cover.

3. Remove the four screws that hold the amplifier module from the far end opposite the connector.

4. Remove the amplifier by lifting its end up and disconnecting from the connector.

5. The amplifier may be replaced by following this procedure in reverse order.

6. Check the amplifier 10 amp fuse located on the DC Supply Board, A6, and replace it if necessary.

7. After an amplifier has been replaced, readjust its gain. Refer to Section 4.

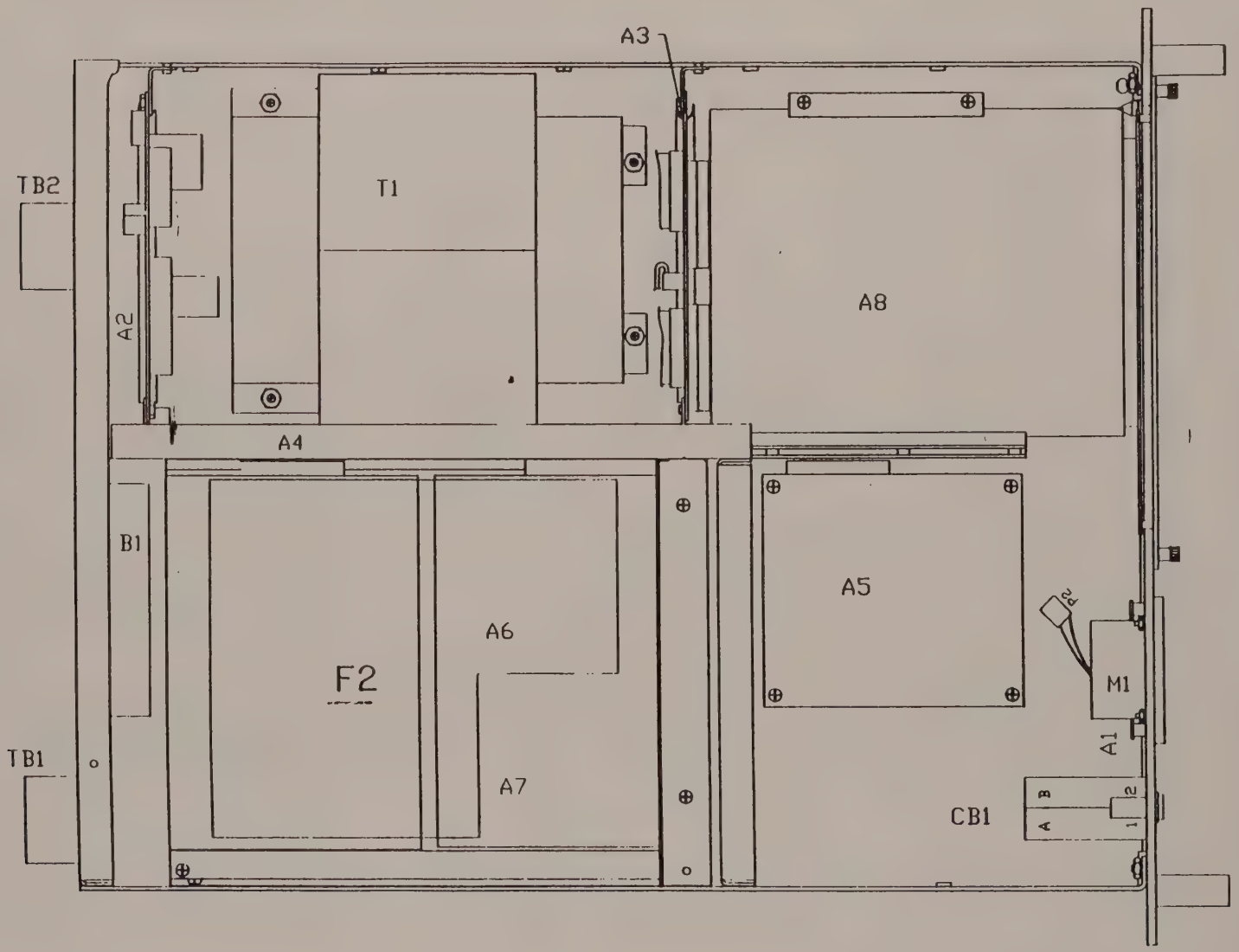


FIGURE 6-1
MODULE LOCATION

TOP ASSEMBLY REPLACEABLE PARTS
FOR 1501L
TOP ASSEMBLY NO: 4005-403-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4005-700-1	PC ASSY, INDICATOR	16067	1.0
A2	4005-705-1	PC ASSY, RANGE/RELAY	16067	1.0
A3	4005-702-1	PC ASSY, OSCILLATOR INTERFACE	16067	1.0
A4	4005-703-1	PC ASSY, MOTHER	16067	1.0
A5	4005-704-1	PC ASSY, CURRENT LIMIT	16067	1.0
A6	4008-712-1	PC ASSY, DC SUPPLY	16067	1.0
A7	4009-423-2	PC ASSY, HEATSINK, SW AMP	16067	1.0
A8	4007-407-2	PC ASSY, MODULE OSC.	16067	1.0
B1	241180	FAN, 4", 48 VDC	23936	1.0

TOP ASSEMBLY REPLACEABLE PARTS
FOR 751L
TOP ASSEMBLY NO: 4005-405-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4005-700-1	PC ASSY, INDICATOR	16067	1.0
A2	4005-705-2	PC ASSY, RANGE/RELAY	16067	1.0
A3	4005-702-1	PC ASSY, OSCILLATOR INTERFACE	16067	1.0
A4	4005-703-1	PC ASSY, MOTHER	16067	1.0
A5	4005-706-2	PC ASSY, CURRENT LIMIT	16067	1.0
A6	4008-712-2	PC ASSY, DC SUPPLY	16067	1.0
A7	4009-423-3	PC ASSY, HEATSINK, SW AMP	16067	1.0
A8	4007-407-2	PC ASSY, MODULE OSC.	16067	1.0
B1	241180	FAN, 4", 48 VDC	23936	1.0

SECTION 7

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and a list of replaceable parts. The list includes the parts description and California Instruments part numbers.

7.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the subassembly where the component is located. (PARENT ITEM NO.)

c. Component reference designator. (SEQ NO.)

d. Component description.

e. Component manufacturers' FSCM number. (VENDOR)

f. California Instruments' part number (COMPONENT ITEM NO.)

All replaceable part orders should be addressed to:

California Instruments
Attention: Customer Service
9025 Balboa Avenue
San Diego, California 92123-1509

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waddon,Surrey	GB
0000S(28564)	OPCDA (Refac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
0000Z(32745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(551123)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	Lafrance	Philadelphia	PA
000AH(54363)	Jan Crystal	Ft. Myers	CA
000AL(534959)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AN	Rite Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(626443)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(618377)	Semi Processors, Inc.	San Jose	CA
000AW	Wirbon	Chatsworth	CA
000AX(638787)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(612711)	Fujitsu	Santa Clara	CA
000BA(619644)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BG(559823)	Electronic Essentials	Woodside	NY
000BE(570856)	Kel-Am	Elgon	MO
000BF(552855)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(564186)	Micro Power Systems	Santa Clara	CA
000BJ(067776)	Robinson Nugent	New Albany	IN
000BL(613150)	Beau Products (Vernitron)	Laconia	NH
000BM(917255)	Corebinder (Certain Aj & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Iecbo	Bagnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00944	Metal-Cal Div.. Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Colecraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	PyroFilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Claires Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capac, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcoo Inc.	Chicago	IL
05278	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loomis Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stanton, Avco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07383	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burlington	IA
07910	Use Code #15818		
08028	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Asphenol)	Garden Grove	CA
08289	Dilan Delbert Co.	Pomona	CA
08353	Bristol Co. of Canada	Toronto, Ont	Canada
08730	Oakey & Barton (Vaseline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12408	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13606	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semicon Corporation	Newbury Park	CA
14606	Elwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Rollinsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Amatom EMI (Rodan Div)	Anaheim	CA
15636	Elec-Trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amico Teledyne, Inc.	Mt. View	CA
15912	Analog	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Unimax	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Sciame Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	Robison Company	Hawthorne	CA
21404	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23936	Plantron, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Inc.	Tempe	AZ
24536	Pereico, Inc.	Paramount	CA
24911	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Somerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26403	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Battler, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Corp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	INB Electronic Products	Santa Fe Springs	CA
27683	Varo, Inc.	St. Garland	TX
27735	P-Dyne Electronics	Bridgeport	CT
27832	Nugnes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28606	Schlin Ltd.	Rendale Ont.	Canada
29372	Resnord Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segunde	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aswid Engineering, Inc.	Laconia	NH
30897	Dorsan Company	Sylmar	CA
30983	Electra/Midland (Repco/ Electra)	San Diego	CA
31837	Budwig Mfg. Co.	Ramona	CA
31951	Trilridge, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Colbert Corp.	Irvington	NJ
34238	Allis Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Hudson	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eastontown	NJ
50811	Mouser Corp.	Santee	CA
51167	Acies Electronics, Inc.	Franchtown	NJ
51506	Accurate Screw Machine Co.	Hutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52769	Timco	Los Angeles	CA
53076	Elatec, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camerillo	CA
55122	Sametr, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57540	United Chemi-Con Corp.	Philadelphia	PA
57956	Kel-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milpitas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61539	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Bemistron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Microncis, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermonic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72793	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73736	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Lovitan Mfg. Co.	Little Neck	NY
75915	Littlefuse, Inc.	Des Plaines	IL
76385	Miner Rubber Co., Inc.	Bloomfield	NJ
77042	Packet Eng. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Patwin Div	Waterbury	CT
77342	Potter and Bluefield Div, AMF	E. Princeton	IN
78189	Shakeproof Div. IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corp.	New Rochelle	NY
80031	Repco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81295	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Roco Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
83480	Brady W.H. Co.	Milwaukee	WI
86684	MCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Usaco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91947	National Tel-Tronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93083	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94696	Monocrafft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	No. Andover	MA
95303	ACA	Clmcinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95546	Arnold Engineering Co.	Marengo	IL
95987	Wackenser Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Tech, Inc.	Gardena	CA
98291	Sealecto Corp.	Mamaroneck	NY
98376	Ipre Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99017	Protective Closures Co., Inc. (Capluge Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delevan	NY
99742	Permacell	New Brunswick	NJ
99743	INC	Hayward	CA
99800	Delevan Electronics Corp.	Aurora	NY

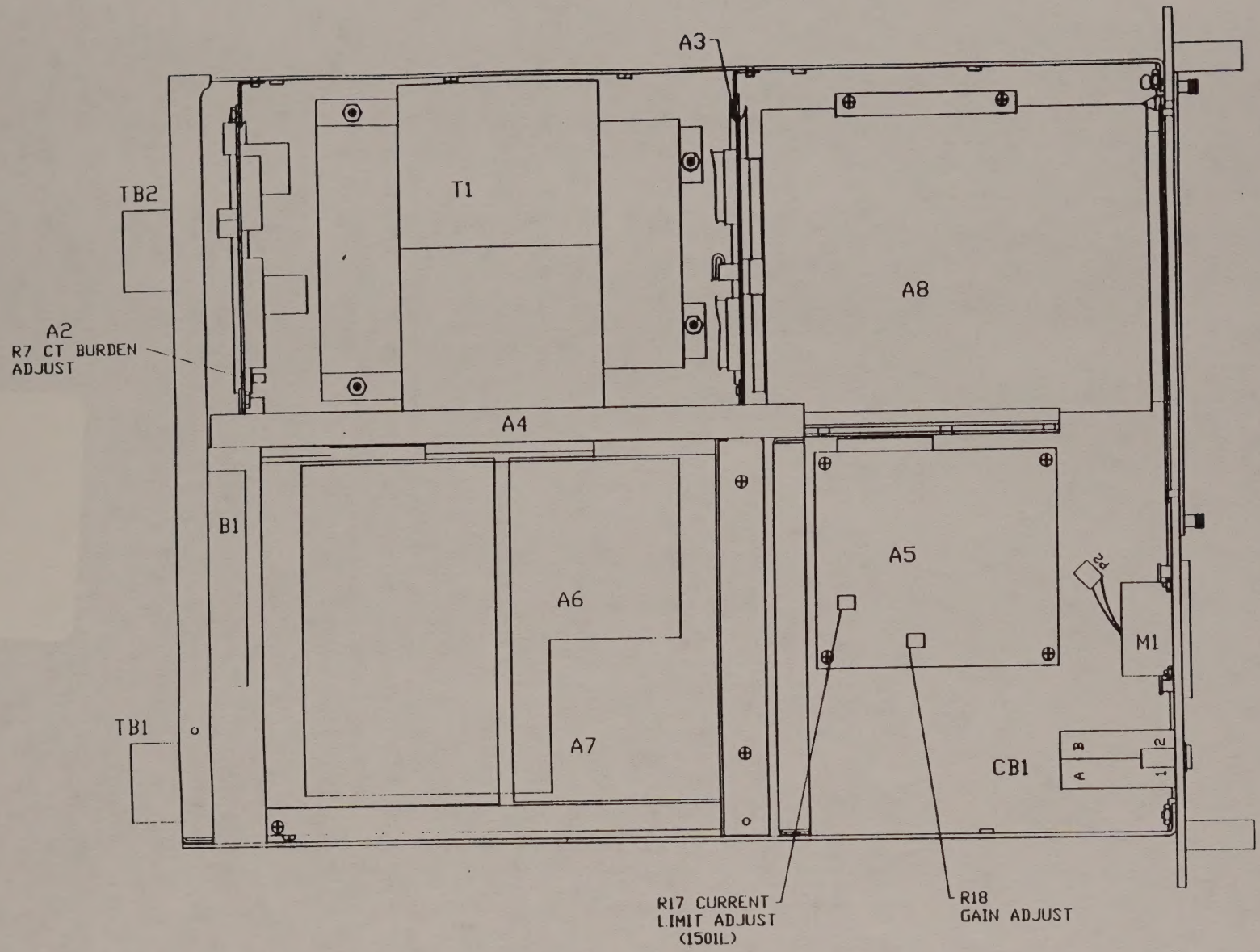


FIGURE 4-1

INTERNAL ADJUSTMENTS AND JUMPER LOCATIONS

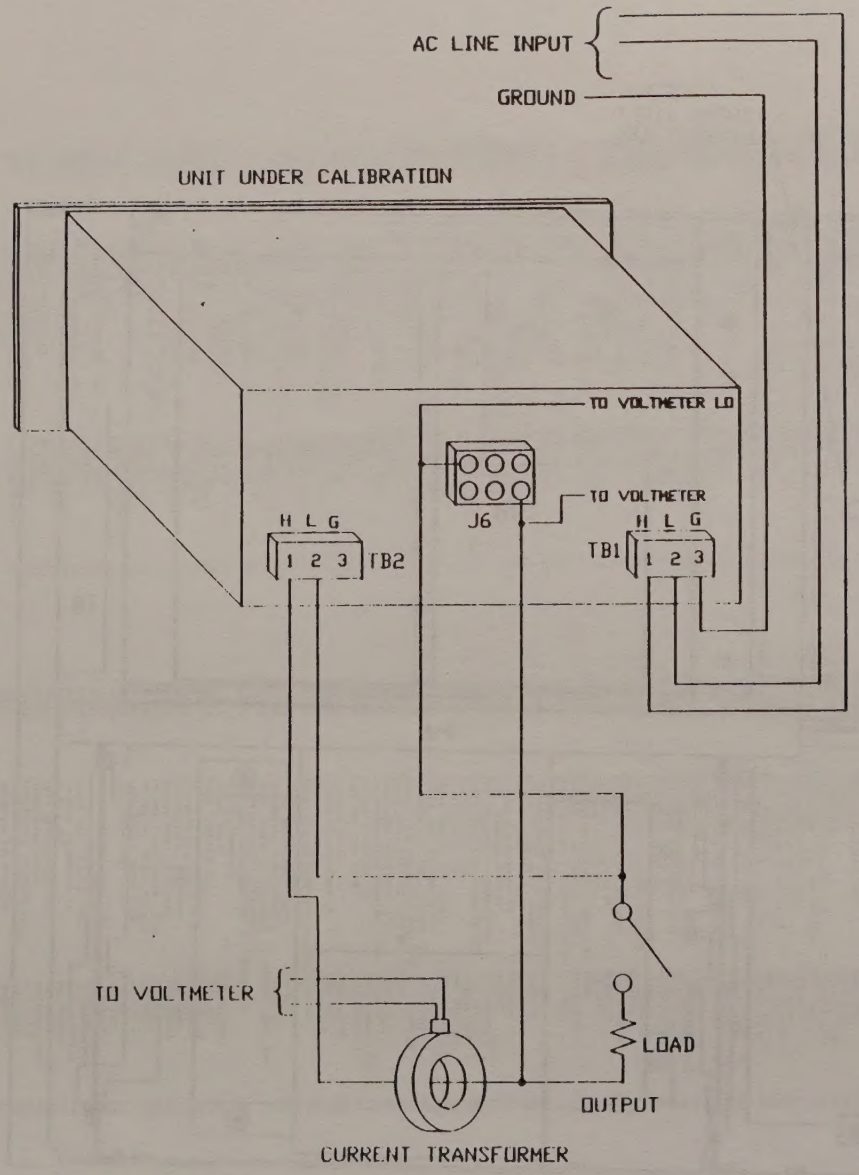


FIGURE 4-2
EQUIPMENT HOOKUP FOR
PERIODIC CALIBRATION

MP MASTER
MA27956